Observations of deep convective influence on stratospheric water vapor and its isotopic composition

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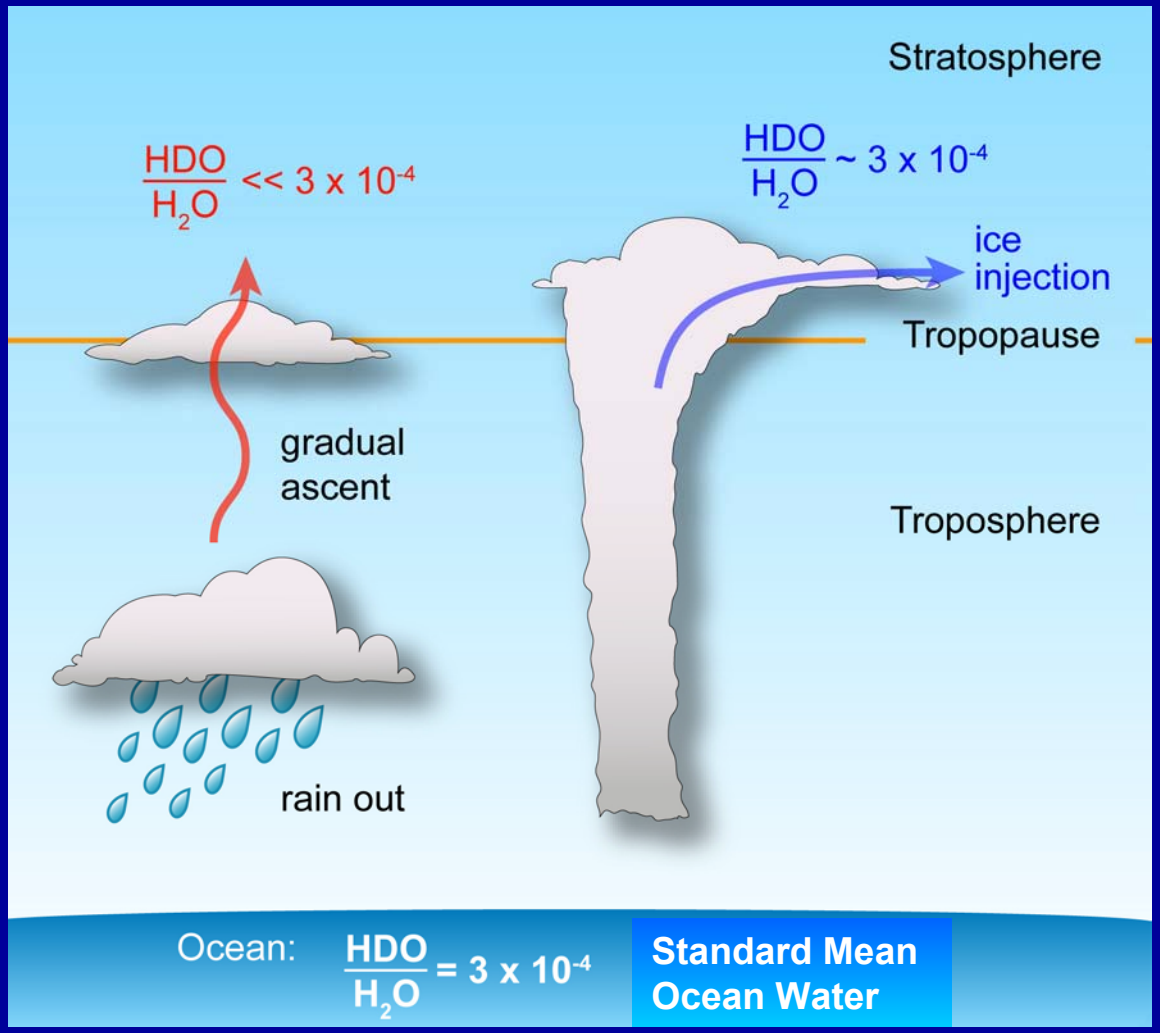
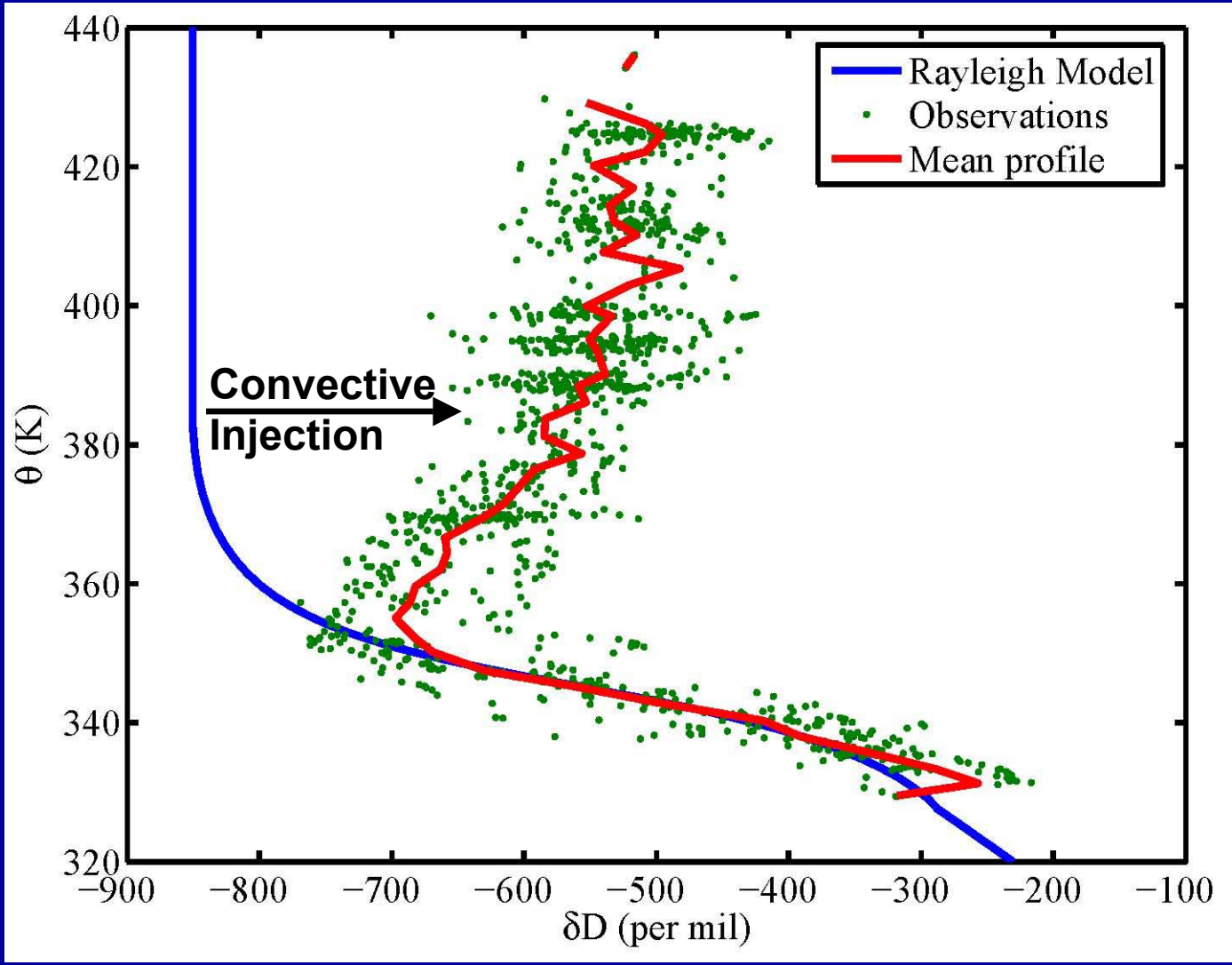
Water isotopes as tracers of Convection

- HDO condenses more readily than H_2O
- Rainout leads to HDO depletion
- Ice injection can make the stratosphere “Heavy”
- *In situ* water isotope measurements can offer a tracer for the condensation history of air parcels



$\delta D = 1000 (HDO/H_2O/SMOW - 1)$

In situ profiles of δD indicate convective input

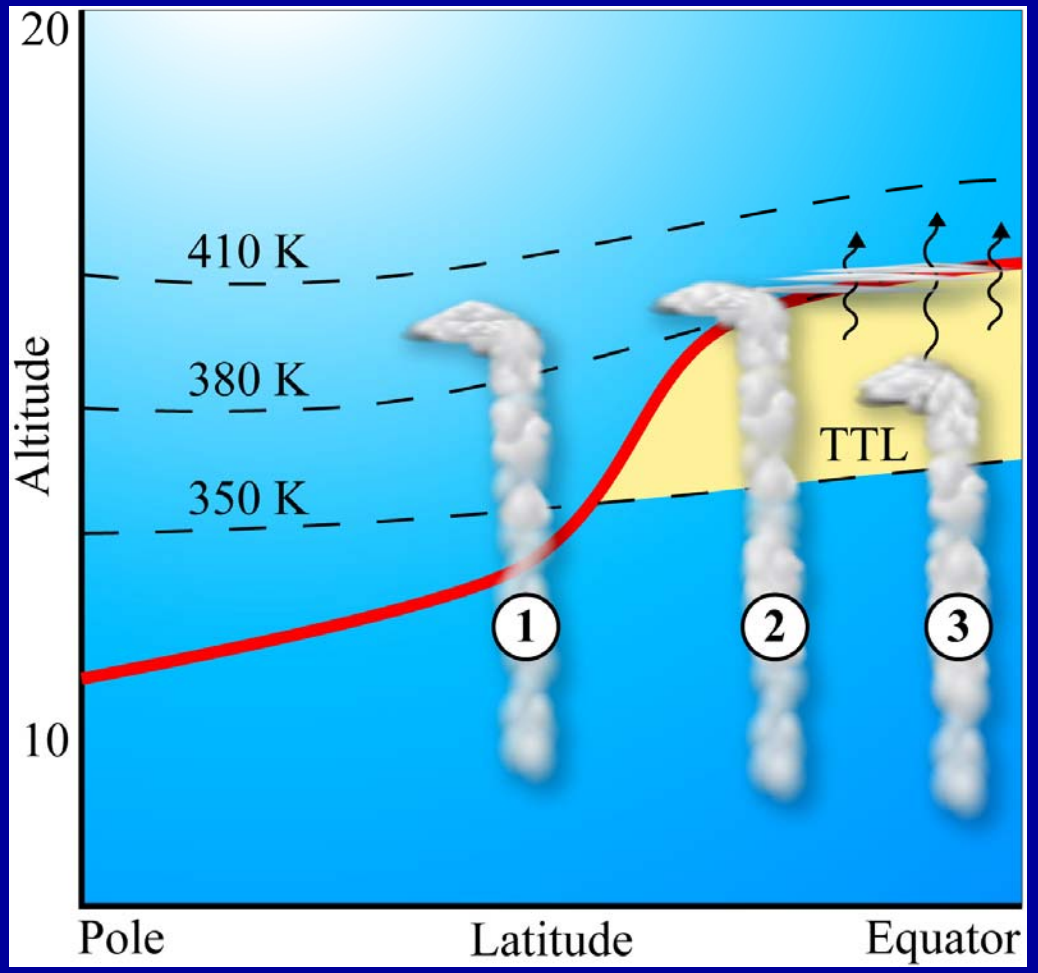


Observations are the descents into San Jose, Costa Rica during CR_AVE: 20060130, 20060201, 20060206, 20060207, 20060209

Possible Hydration pathways

Use H_2O and H_2O isotopes observations identify:

1) **Convection in the mid-latitude overworld**
2) **Convection into the tropical stratosphere**
3) Convection into the TTL



Storm Track July 7, 2005

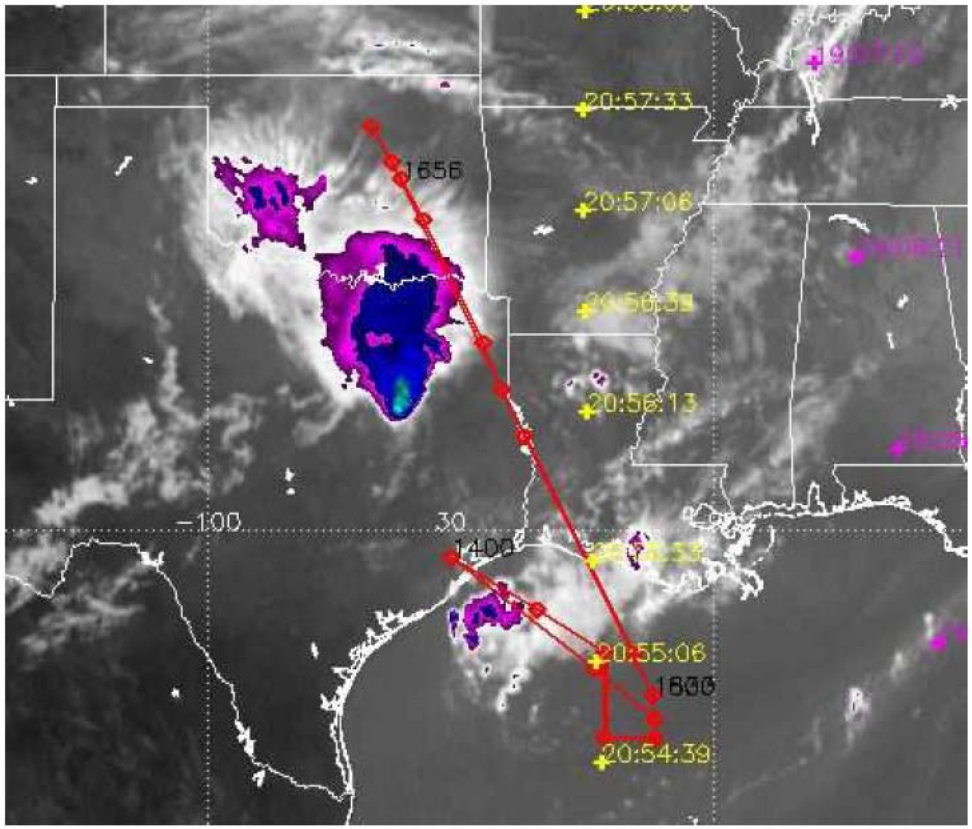
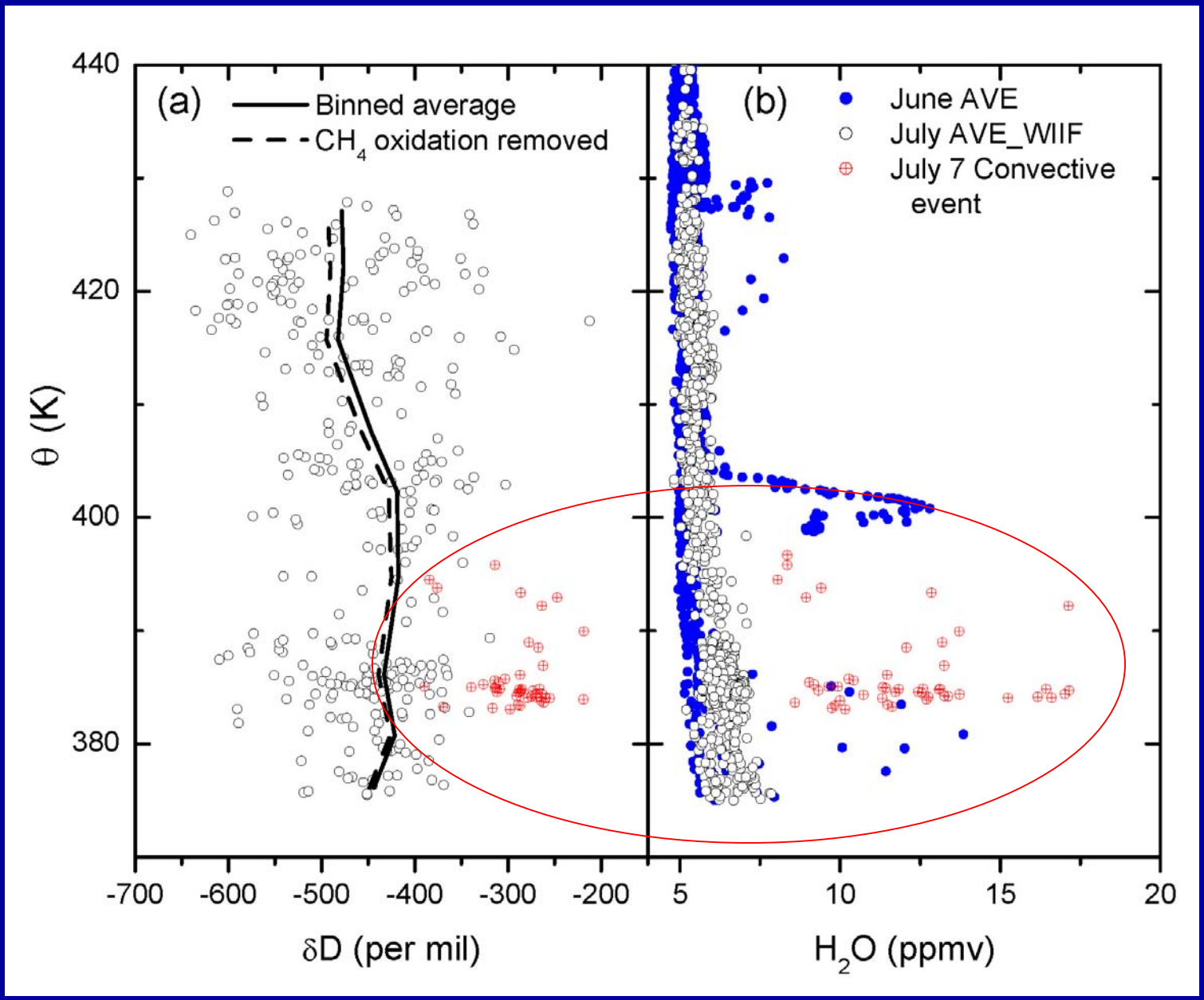


Figure 2: Flight track overlaid on the IR satellite image (Courtesy Lenny Pfister).

Overworld stratosphere water vapor



Water isotope values resulting from simple mixing

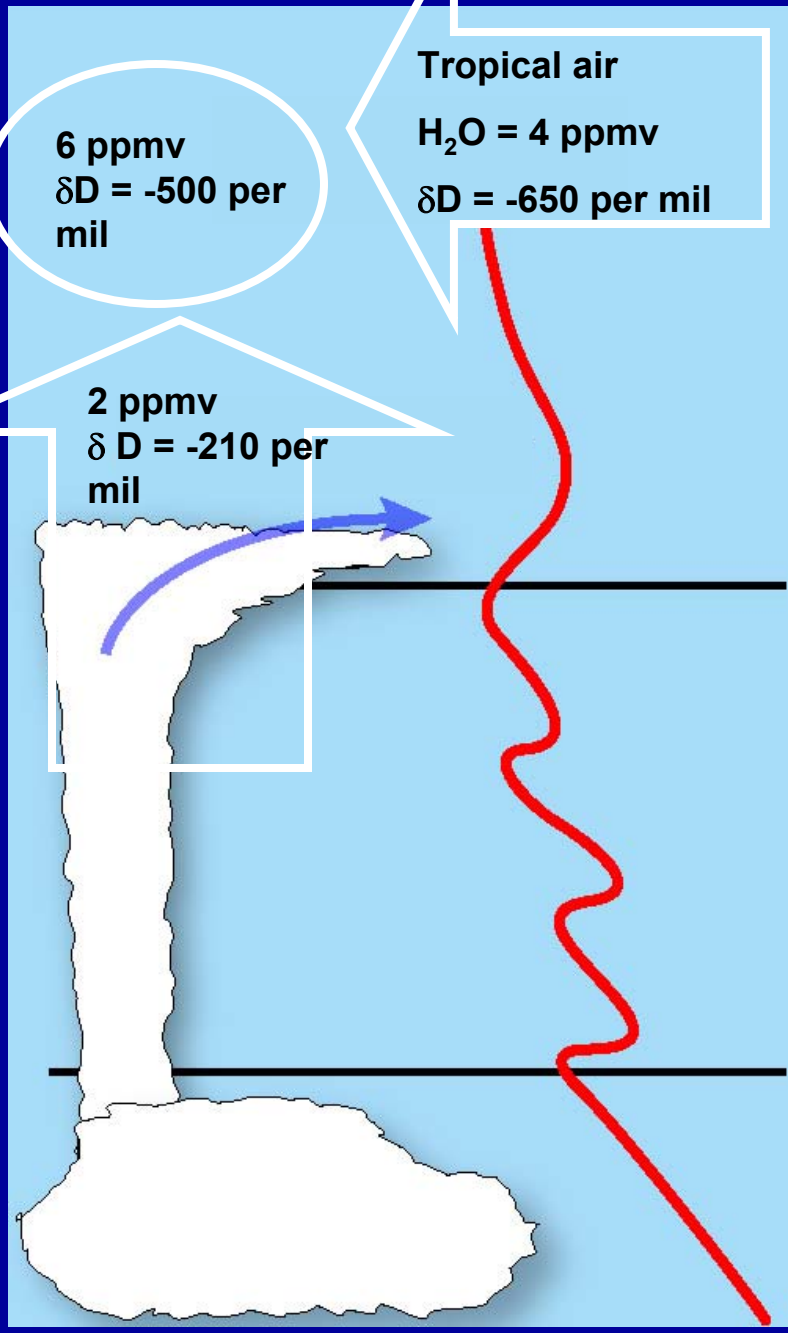
Rough calculation

Tropical source: 4 ppm @ -650 per mil
Convected source: 2 ppm @ -210 per mil

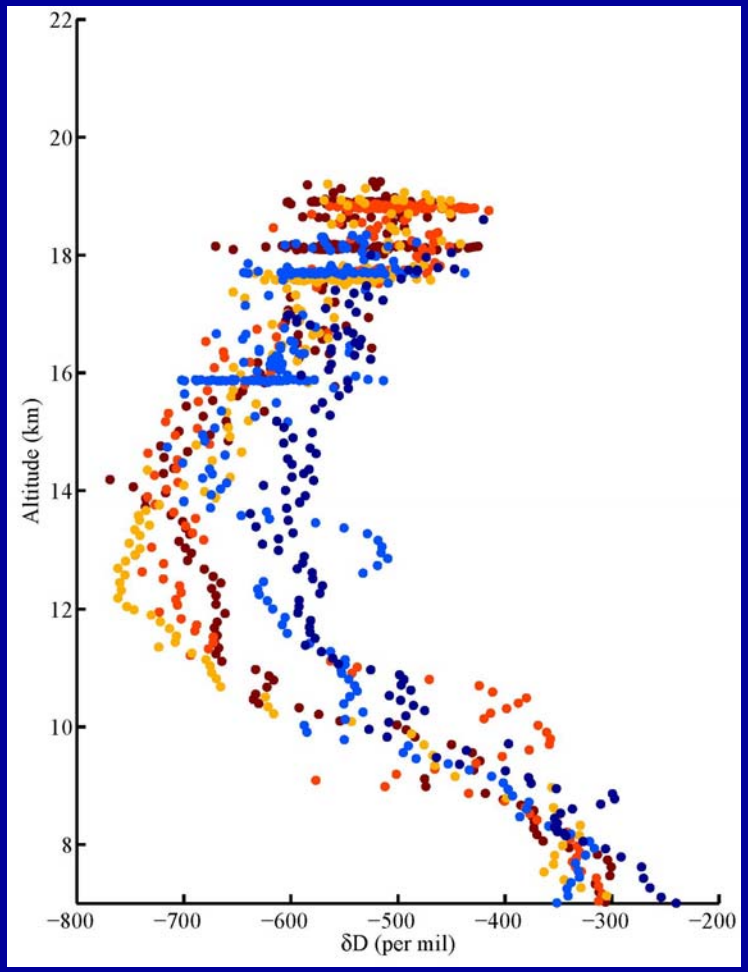
$\delta D = 4/6(-650 \text{ per mil}) + 2/6(-210 \text{ per mil})$
$\delta D = -500$ per mil

Observed:
$\delta D = -460$ per mil

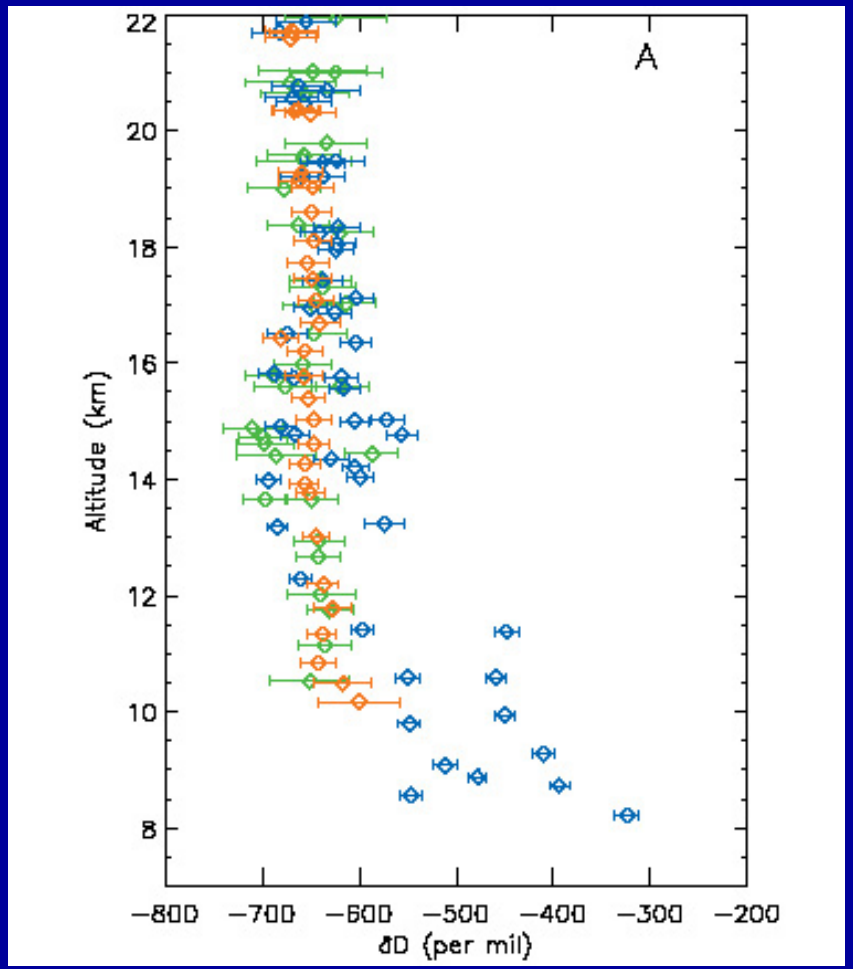
Convection is a significant source of water vapor in the overworld stratosphere (… in July …over Houston …)



In situ tropical profiles



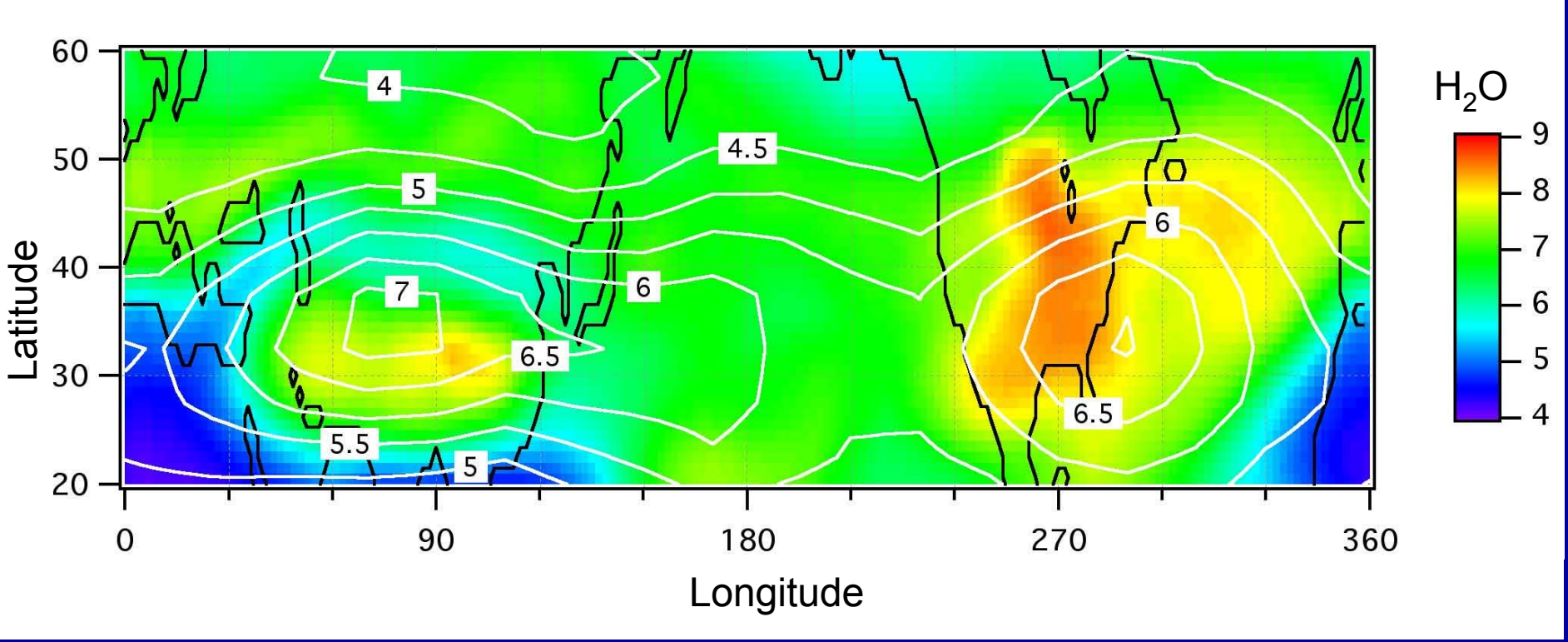
ATMOS tropical profiles



In situ profiles show more variability and higher stratospheric δD. Above 16 km the differences are within the uncertainties, but this is still an important issue to resolve. δD_e is a major uncertainty.

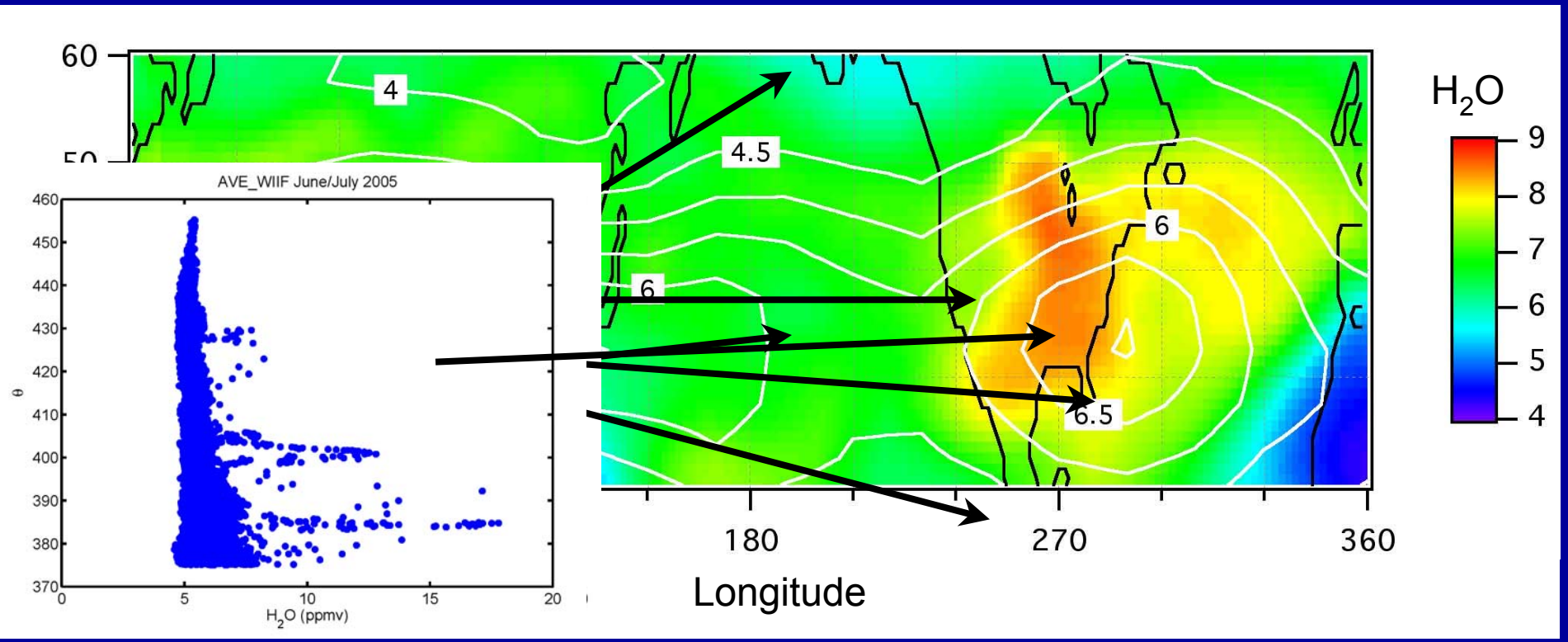
Kuang et al., *GRL*, 2003.

MLS data show H_2O maxima over convectively active areas

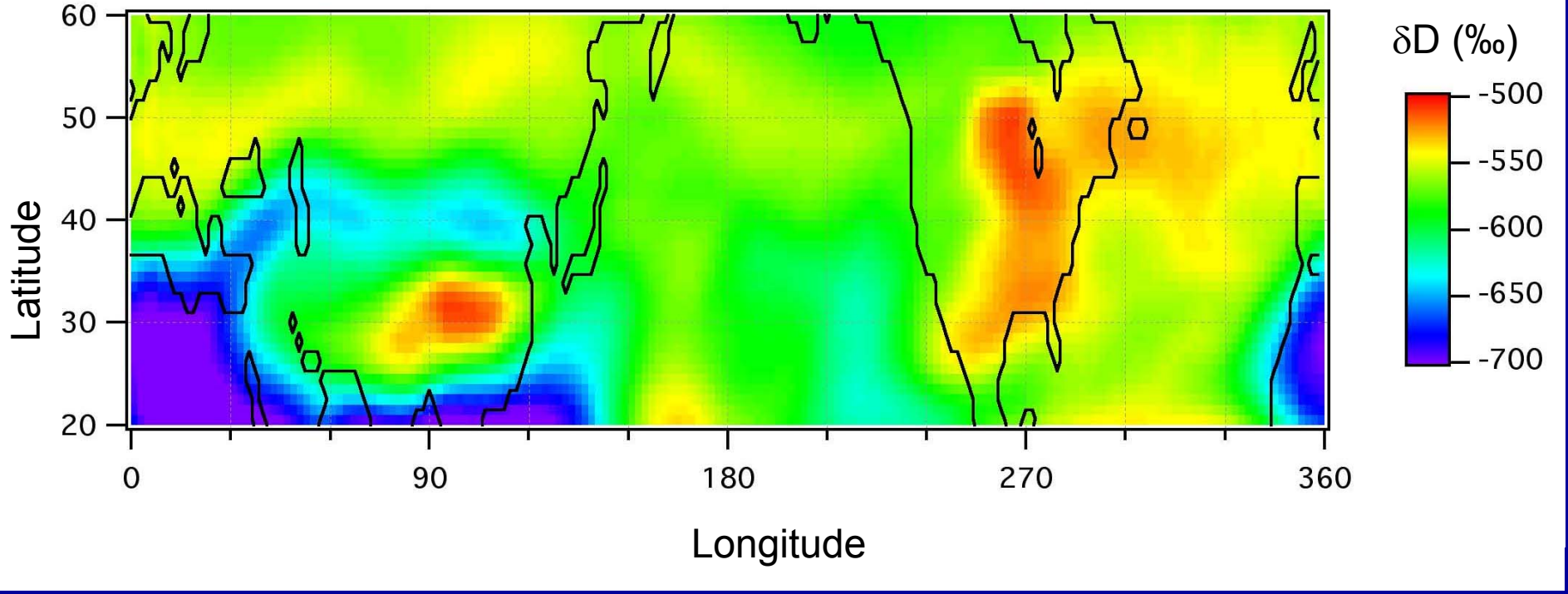


Average H_2O at θ = 380 K for July 2005. Simulated data are colored, observations from MLS are shown as contours. Method from *Dessler and Sherwood, JGR,* 2004

In situ observations Convective influence in the middleworld stratosphere



Geographic and seasonal variability of convective influence on water isotopes



Modeled water isotope depletion on the 380 K surface. δD_e = -650 per mil, δD_c (ice + vapor) = -280 per mil. The model is from *Dessler and Sherwood, JGR 2004.*

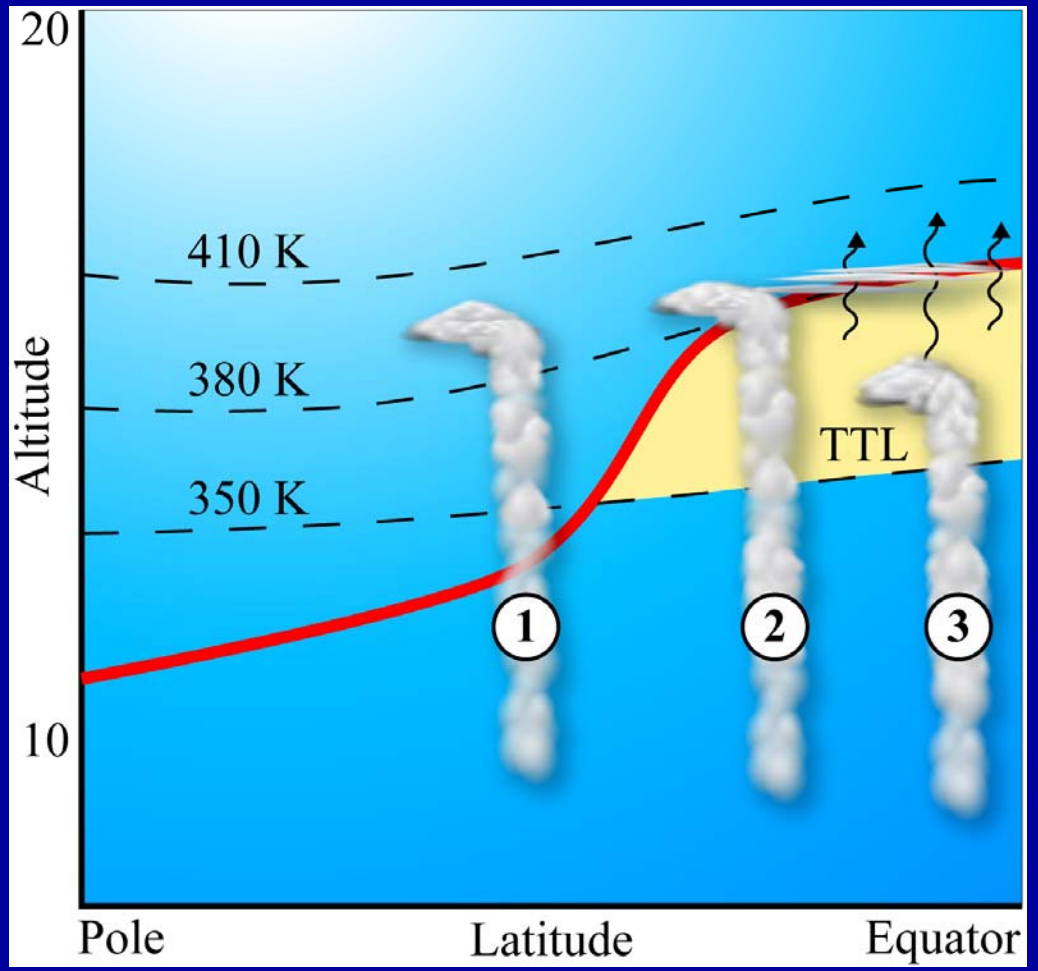
Hydration pathways

H_2O and H_2O isotopes observations identify:

1) Ice lofting and convective outflow above 380 K and up to 420 K
2) Ice lofting into the tropical stratosphere
3) Convective influence in the TTL

The isotopically heavy stratosphere indicates that the sum of 1 – 3 is significant.

The relative contribution of each is not yet determined.



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